4. RISK ASSESSMENT METHODOLOGY AND TOOLS

A risk assessment is the process of evaluating the potential loss of life, personal injury, and economic and property damage that could result from identified hazards. Identifying potential hazards and vulnerable assets allows planning personnel to address and reduce hazard impacts and allows emergency management personnel to establish early response priorities. Results of the risk assessment are used in subsequent mitigation planning processes, including determining and prioritizing mitigation actions that reduce each jurisdiction's risk from each hazard. Past, present, and future conditions must be evaluated to assess risk most accurately for all participating jurisdictions. The process focuses on the following elements:

- **Identify Hazards of Concern**—Use all available information to determine what types of hazards may affect a jurisdiction.
- **Profile Each Hazard**—Understand each hazard in terms of:
  - Extent—The potential severity of each hazard
  - Location—Geographic area most likely to be affected by the hazard
  - Previous occurrences and losses
  - Impacts of climate change
  - Probability of future hazard events
- **Assess Vulnerability and Impacts**—Use all available information to estimate to what extent populations and assets may be adversely affected by a hazard now and in the future:
  - Determine vulnerability—Estimate the total number of assets in the jurisdiction that are likely to experience a hazard event if it occurs by overlaying hazard maps with the asset inventories.
  - Estimate potential impacts/losses—Assess the impact of hazard events on the people, property, economy, and lands of the region, including estimates of the losses associated with potential damage or cost that can be avoided by mitigation.
  - Evaluate future changes that may affect vulnerability and impacts—Analyze how demographic changes, projected development, and climate change impacts can alter current vulnerability and potential impacts.

The Sussex County risk assessment was updated using the following best-available information:

- The previous HMP's building stock was utilized as the foundational database and was upgraded with updated tax assessor data from MOD-IV, parcel data from Sussex County, building footprints from Microsoft; and 2022 RSMeans cost adjustment values.
- 2020 Decennial Census population data and 2017-2021 American Community Survey 5-year Population Estimates were utilized.
- Critical facilities were updated and reviewed by the Planning Partners.
- Lifelines were identified in the critical facility inventory to align with FEMA's community lifeline definition.
- FEMA's Hazus program was used to estimate potential impacts from the flood, wind, and seismic hazards.
- Best-available hazard data were used, as described in this section.

4.1 RATING PROBABILITY OF OCCURRENCE

Based on records of previous hazard events and consideration of potential future changes that could affect the frequency of future events, the risk assessment assigns a rating for the probability of occurrence of each hazard in the future. These ratings were assigned as follows:

- Unlikely—not likely to occur or less than 1 percent annual chance of occurring
- Rare—between 1 and 10 percent annual chance of occurring
- Occasional—between 10 and 100 percent annual chance of occurring
- Frequent—occurs multiple times a year

4.2 ASSET INVENTORIES

Sussex County assets were identified to assess potential vulnerability and impacts associated with the hazards of concern. The HMP update assesses vulnerability and potential hazard impacts for the following types of assets: population, buildings, critical facilities, community lifelines, the environment, and new development. Each asset type is described below. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual properties.

4.2.1 Population

Statistics from the 2020 Decennial Census population estimate and 2017-2021 American Community Survey (ACS) 5-year estimate were used to estimate the vulnerability of and potential impacts on the County's population. Socially vulnerable populations included in the risk assessment are people under 5 years old or over 65 years old, people living below the poverty level, non-English speaking individuals, and people with a disability.

FEMA's Hazus program was used to estimate potential impacts on people from flood, seismic, and wind hazards. The Hazus model estimates sheltering requirements and potential deaths and injuries.

4.2.2 Buildings

The risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate hazard vulnerability and impacts.

The general building stock from the last hazard mitigation plan was utilized as the initial building stock dataset. This dataset was reviewed for accuracy and was upgraded where change was identified in the most-recent MOD-IV tax assessor data, 2023 parcel data from Sussex County, and 2022 building stock footprints sourced from Microsoft. The building inventory attributes were updated using updated parcels and tax assessor information. Attributes provided in the associated files were used to further define each structure, such as year built, number of stories, basement type, occupancy class, and square footage. The centroid of each building footprint was used to estimate the building location.

Buildings were assigned to occupancy classes define in Hazus. To facilitate analysis and presentation of results, the Hazus classes were condensed into the categories of residential (including multi-family and single-family), commercial, industrial, and other (agricultural, religious, governmental, and educational).

Structural and content replacement cost values (RCV) were calculated for each building using the available assessor data, the building footprint, and RSMeans 2022 values. RCV is the cost of returning a destroyed asset to its pre-damaged condition using present-day cost of labor and materials. Total RCV consists of both the structural cost to replace a building and the estimated value of contents of the building. Content value was estimated as 50 percent of the structure value for residential buildings, and 100 percent of the structure value for non-residential buildings. The analysis used a location factor associated with zip-code, as follows:

- Zip Codes starting with 74:
  - Residential: 1.16
  - Non-Residential: 1.12
- Zip Codes starting with 78:
  - Residential: 1.14
  - Non-Residential: 1.11

4.2.3 Critical Facilities and Community Lifelines

A critical facility inventory, which includes essential facilities, utilities, transportation features and user-defined facilities, was created by the Planning Partnership. The development involved a review for accuracy, additions, or deletions of new or moved critical assets, identification of backup power for each asset (if known) and whether the critical facility is considered a lifeline in accordance with FEMA's definition (refer to Appendix G, Critical Facilities).

> A lifeline provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security (FEMA).

4.2.4 Environment and Land Use

Land cover data created by NJDEP (2015) was converted from a raster to a vector polygon, which informed spatial mapping of built and natural land use areas. The built land use areas were defined as urban areas and include developed open space, and low, medium, and high intensity locations. Non-urban areas were classified as agricultural, barren land, forest, rangeland, water, and wetlands land use categories.

4.2.5 New Development

New development in the planning area was defined as development that occurred over the last 5 years and development that is expected to occur over the next 5 years. Each jurisdiction was asked to provide a list by address of major development that has taken place within these timeframes. The location of new development projects was submitted via ArcGIS Survey123. The new development is listed in Chapter 3, and hazard vulnerability analysis results are presented as a table in each annex in Volume II.

A geographic information system (GIS) analysis was conducted to determine hazard exposure of these development sites. Projects built on multiple parcels were assessed as one unit. If one parcel identified within the project boundary intersected a spatial hazard layer, the entire project was considered "exposed" to the hazard area of concern.

4.3 METHODOLOGY

Sussex County used standardized tools, combined with local, state, and federal data and expertise to assess potential vulnerability and losses associated with hazards of concern. Three levels of analysis were used, depending upon the data available for each hazard:

- **Qualitative Review—**This analysis includes an examination of historical impacts to understand potential impacts of future events of similar size. Potential impacts and losses are discussed qualitatively using best-available data and professional judgment.
- **Vulnerability Analysis—**This analysis involves overlaying available spatial hazard layers, for hazards with defined locations, on asset mapping in GIS to determine which assets are located in the hazard area.
- **Loss Estimation**—The FEMA Hazus modeling software was used to estimate impact in terms of potential losses for the following hazards: flood, earthquake, and hurricane.

Table 4-1 summarizes the type of analysis conducted by hazard of concern.

Table 4-1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities
Dam Failure	Q	Q	Q
Disease Outbreak	Q	Q	Q
Drought	Q	Q	Q
Earthquake	V, L	V, L	V, L
Flood	V, L	V, L	V, L
Geological Hazards	V	V	V
Hazardous Materials	V	V	V
Hurricane	L	L	L
Infestation	Q	Q	Q
Nor'easter	Q	Q	Q
Severe Weather	Q	Q	Q
Severe Winter Weather	Q	Q	Q
Wildfire	V	V	V

Notes: V = vulnerability analysis; L = loss estimation; Q = qualitative review

4.3.1 Hazus

Hazus is a GIS-based software tool developed by FEMA that uses engineering and scientific risk calculations to estimate damage and loss. Its use is accepted by FEMA and provides a consistent framework for assessing risk across a variety of hazards. Hazus uses GIS technology to produce detailed maps and analytical reports that estimate direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Table 4-2 lists the levels of analysis that can be conducted using the Hazus software depending on the hazard and inventory data provided.

Table 4-2. Summary of Hazus Analysis Levels

Level 1	Hazus provides hazard and inventory data with minimal outside data collection or mapping.
Level 2	Hazus-provided hazard and inventory data are augmented with more recent or detailed data for the study region, referred to as “local data”
Level 3	The built-in Hazus loss estimation models are adjusted for the hazard loss analyses, usually in conjunction with the use of local data.

Hazus damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and economic impact) depending on the hazard and available local data. Hazus’ open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage.

For this HMP, losses were estimated in Hazus using depth grids for the flood analysis and probabilistic (mean return period) analyses for hurricane wind and seismic hazards. The probabilistic model generates estimated damage and losses for specified return periods (e.g., 100- and 500-year).

4.3.2 Hazard-Specific Methodologies

Dam Failure

To assess the vulnerability of Sussex County to dam failure and its associated impacts, a qualitative review was conducted.

Disease Outbreak

All of Sussex County is at risk from the impacts of disease outbreak events. A qualitative review was conducted to assess the county’s vulnerability to this hazard of concern.

Drought

All of Sussex County is at risk from the impacts of drought events. A qualitative review was conducted to assess the county’s vulnerability to this hazard of concern.

Earthquake

Vulnerability Analysis

Ground shaking is the primary cause of earthquake damage to structures, and soft soils amplify ground shaking. The National Earthquake Hazard Reductions Program (NEHRP) has developed soil classifications defined by their ability to amplify ground shaking. The soil classification system ranges from Type A to Type E, where Type A represents hard rock that reduces ground motions from an earthquake and Type E represents soft soils that amplify ground shaking and increase building damage (an additional classification, Type F, represents soils with special circumstances that require additional analysis for seismic evaluations). Types D and E are the NEHRP soil types most susceptible to amplified ground motion during an earthquake.

A vulnerability analysis was conducted for the county’s assets using NEHRP soil data sourced from NJDOT and Sussex County (2012, 2021). The vulnerability analysis defined the hazard area as all areas with Type C and D soil

types (the two most vulnerable soil types present in Sussex County). Assets with their centroid in the hazard areas were totaled to estimate the numbers and values vulnerable to these soil types.

Loss Estimation

A probabilistic assessment was conducted for the 500-year and 1,000-year mean return period earthquake events through a Level 2 analysis in Hazus. The probabilistic method uses information from historical earthquakes and inferred faults, locations, and magnitudes to compute probable ground shaking levels, by Census tract, for a seismic event of a selected a recurrence period. Hazus' potential loss estimates are acceptable for the planning-level purposes of this HMP.

Damage estimates were calculated for losses to buildings (structural and non-structural) and contents. Structural losses include load carrying components of the structure. Non-structural losses include those to architectural, mechanical, and electrical components of the structure, such as nonbearing walls, veneer and finishes, HVAC systems, boilers, etc.

Flood

The 1- and 0.2-percent annual chance flood events were examined to evaluate the county's risk from the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as NFIP. The following data were used to evaluate vulnerability and determine potential future losses for this plan update:

- FEMA's effective Sussex County Digital Flood Insurance Rate Map (DFIRM) dated September 29, 2011, with a latest letter of map revision of October 2, 2014.
- A depth grid created from the 2011 effective FEMA Digital Flood Insurance Rate Map (DFIRM) and a 2-foot cell size digital elevation map provided by NJDEP.

The effective Sussex County FEMA DFIRM published in 2011 was used to evaluate vulnerability and determine potential future losses. The depth grid generated using the DFIRM and 2-foot cell size digital elevation map was integrated into the Hazus riverine flood model and used to estimate potential losses for the 1-percent annual chance flood event.

Vulnerability Analysis

To estimate vulnerability to the 1-percent- and 0.2-percent annual chance flood events, the DFIRM flood boundaries were overlaid on the centroids of updated assets. Centroids that intersected the flood boundaries were totaled to estimate the building RCV and population vulnerable to the flood inundation areas. A Level 2 analysis was performed. Critical facility and building inventories were formatted to be compatible with the Hazus Comprehensive Data Management System.

Loss Estimation

The Hazus riverine flood model was run to estimate potential losses in Sussex County for the 1-percent annual chance flood event. A Level 2 analysis was performed for the building stock. Buildings located within the floodplain were imported as user-defined facilities to estimate potential losses at the structural level. Hazus calculated the estimated potential losses to the population (default 2020 U.S. Census data), potential damage to the general building stock, and potential damage to critical facilities based on the depth grids generated and the default Hazus damage functions in the flood model.

Geological Hazards

To estimate vulnerability to geological hazards, the following hazard layers were overlaid on the centroids of updated assets: carbonate karst, abandoned mines (with a 0.25-mile buffer), high landslide risk (>20 percent slopes), and moderate landslide risk (15 to 20 percent slopes). Centroids that intersected the hazard boundaries were totaled to estimate the building RCV and population vulnerable to the geologic hazard areas.

Hazardous Materials

To estimate vulnerability to hazardous materials, the following hazard layers were overlaid on the centroids of updated assets: 1-mile buffer around hazardous materials sites, 1-mile buffer around hazardous materials rail routes, 1-mile buffer around hazardous materials roadway routes, and a 50-mile buffer around Indian Point. Centroids that intersected the hazard boundaries were totaled to estimate the building RCV and population vulnerable to the hazardous materials hazard areas.

Hurricane

A level 2 Hazus Hurricane analysis was performed for the 100- and 500- year mean return periods. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with Sussex County. Hazus contains data on historical hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area, which support the modeling of wind force. Default demographic and updated building and critical facility inventories in Hazus were used for the analysis. Although damage is estimated at the census tract level, results were presented at the municipal level. Because there are multiple census tracts that contain more than one jurisdiction, a density analysis was used to extract the percent of building structures that fall within each tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each jurisdiction.

Infestation

All of Sussex County is at risk from the impacts of infestation events. A qualitative review was conducted to assess the county's vulnerability to this hazard of concern.

Nor'easter

All of Sussex County is exposed and vulnerable to the nor'easter hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A qualitative review was conducted to assess the county's vulnerability to this hazard of concern.

Severe Weather

All of Sussex County is exposed and vulnerable to the severe weather hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A qualitative review was conducted to assess the county's vulnerability to this hazard of concern.

Severe Winter Weather

All of Sussex County is exposed and vulnerable to the severe winter weather hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A qualitative review was conducted to assess the county's vulnerability to this hazard of concern.

Wildfire

Wildfire fuel hazard mapping from the New Jersey Forest Fire Service (2009) was referenced to delineate wildfire hazard areas. The high, very high, and extreme risk areas were analyzed. Hazard area boundaries were overlaid on the centroids of updated assets. Centroids that intersected the wildfire hazard areas were totaled to estimate the building RCV and population vulnerable to the wildfire hazard.

4.4 DATA SOURCE SUMMARY

Table 4-3 summarizes the data sources used for the risk assessment for this plan.

4.5 LIMITATIONS

Loss estimates, vulnerability analyses, and hazard-specific impact evaluations rely on the best-available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Approximations and simplifications necessary to conduct such a study
- Incomplete or dated inventory, demographic, or economic parameter data
- The unique nature, geographic extent, and severity of each hazard
- Mitigation measures already employed by the participating jurisdictions
- The amount of advance notice residents have to prepare for a specific hazard event
- Uncertainty of climate change projections

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more. Therefore, potential vulnerability and loss estimates are approximate. These results do not predict precise results and should be used only to understand relative risk. Over the long term, Sussex County will collect additional data and update and refine existing inventories to assist in estimating potential losses.

Potential economic loss is based on the present value of the general building stock using best-available data. The county acknowledges significant impacts may occur to critical facilities and infrastructure as a result of these hazard events, causing great economic loss. However, monetized damage estimates to critical facilities and infrastructure, and economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry such as tourism and the real-estate market were not analyzed.

Table 4-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population	U.S. Census Bureau; American Community Survey 5-Year Estimates	2020; 2021	Digital (GIS)
Building Inventory	Sussex County; NJOGIS, Civil Solutions, Spatial Data Logic; RS Means	2023; 2022	Digital (GIS)
Critical Facilities and Lifelines	Sussex County Planning Partnership and County Jurisdictions; NJGIN	2021; 2023	Digital (GIS)
Digitized Effective FIRM maps	FEMA	2011; 2014	Digital (GIS)
2-Foot Cell Size Digital Elevation Model	NJDEP Bureau of GIS	2023	.csv; .laz
Landslide Hazard Data	NJDEP Bureau of GIS; NJ Office of GIS NJOIT, USGS	2023	Digital (GIS)
NEHRP Soils	NJDOT; Sussex County	2012; 2021	Digital (GIS)
Carbonate/Karst Hazard Data	NJDEP	2023	Digital (GIS)
Abandoned Mines	NJDEP	2021	Digital (GIS)
Wildfire Hazard Data	NJFFS	2009	Digital (GIS)
Rail Network	NJ Transit	2018	Digital (GIS)
Road Network	Sussex County	2021	Digital (GIS)
Hazardous Sites	EPA	2018	Digital (GIS)
Land Cover	NJDEP	2015	Digital (GIS)
New Development Data	Sussex County Planning Partnership and County Jurisdictions	2023	Digital (GIS)

Notes:
EPA = Environmental Protection Agency
FEMA = Federal Emergency Management Agency
NJDEP = New Jersey Department of Environmental Protection
NJDOT = New Jersey Department of Transportation
NJFFS = New Jersey Forest Fire Service
NJGIN = New Jersey Geographic Information Network
NJOGIS = New Jersey Office of Geographic Information Systems
NJOIT = New Jersey Office of Information Technology
USGS = U.S. Geological Survey

4.6 CONSIDERATIONS FOR MITIGATION AND NEXT STEPS

The following are considerations for the next plan update to enhance the risk assessment:

- All hazards
  - Create an updated user-defined general building stock dataset using up-to-date parcels, footprints, and RSMeans values.
  - Utilize updated and current demographic data.
- Dam failure
  - Identify available dam inundation hazard boundary data for high and very high hazard dams to incorporate a quantitative analysis.

- Earthquake
  - Identify unreinforced masonry in critical facilities and privately owned buildings (i.e., residences) by accessing local knowledge, tax assessor information, and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response or recovery efforts at these properties can be developed.
- Flood
  - Update the general building stock inventory to include attributes regarding first floor elevation and foundation type (basement, slab on grade, etc.) to enhance loss estimates.
  - Conduct a Hazus loss analysis for more frequent flood events (e.g., 10- and 50-year flood events).
  - Conduct a repetitive loss area analysis.
  - Continue to expand and update urban flood areas to further inform mitigation.
  - As more current FEMA floodplain data become available (i.e., DFIRMs), update the vulnerability analysis and generate a more detailed flood depth grid that can be integrated into the current Hazus version.
- Geological hazards
  - Continue using the most up to date geologic hazard data available.
- Hazardous materials
  - Utilize the most recent location data for roadways, railways, and hazardous materials sites.
- Hurricane
  - The general building stock inventory can be updated to include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
  - Integrate evacuation route data that are currently being developed.
- Wildfire
  - General building stock inventory can be updated to include attributes such as roofing material, fire detection equipment, or distance to fuels as another measure of vulnerability.